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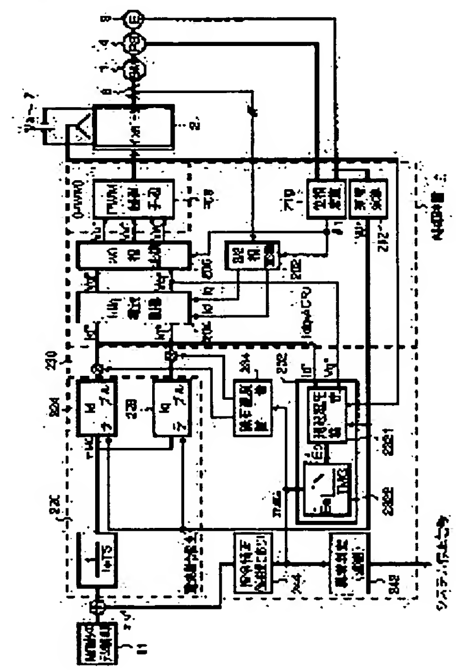
(54) CONTROLLER AND CONTROL METHOD FOR ELECTRIC VEHICLE



(57)Abstract:
PROBLEM TO BE SOLVED: To ensure a good travel control by estimating the magnet temperature of a synchronous machine from an estimated induction voltage and a temperature estimation table thereof and compensating for the output therefrom, depending on the increase of estimated magnet temperature of the synchronous machine.
SOLUTION: A motor controller 5 is provided with a magnet temperature estimating means 232 and a magnet temperature compensating means 234. The magnet temperature estimating means 232 estimates the magnet temperature TMG from the relationship between a temperature estimation table 2322 and an induced voltage E010 estimated by an induced voltage estimating means 2321. The induced voltage increases as the magnet temperature increases, and thereby the motor voltage decreases. Consequently, the power factor fluctuates, and the output torque decreases. So, the magnet temperature compensating means 234 estimates the magnet temperature TMG from the estimated induction voltage with reference to the temperature estimation table 2322 and compensates for the d-axis current Id and the q-axis current Iq. In this way, the fluctuations in the output voltage of a synchronous machine due to the fluctuations of the magnet temperature TMG is compensated for through the compensation of current command values Id*, Iq*.

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CLAIMS

[Claim(s)]
[Claim 1] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control unit of the electric rolling stock equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature it is decided with the ingredient of a permanent magnet that will be an induced voltage presumption means to presume the induced voltage of said synchronous machine, The control unit of the electric rolling stock characterized by establishing a magnet temperature presumption means to presume the magnet temperature of said synchronous machine from the presumed induced voltage of said synchronous machine, and said temperature presumption table, and a magnet temperature-compensation means to compensate the output of said synchronous machine according to the rise of the magnet temperature of said presumed synchronous machine.
[Claim 2] Said magnet temperature-compensation means is the control unit of the electric rolling stock according to claim 1 characterized by amending the current command of said d and q shaft current based on the magnet temperature estimate which is an output value of said magnet temperature presumption means.
[Claim 3] Said induced voltage presumption means Said q shaft electrical-potential-difference command value, said d shaft current command value, The presumed induced voltage of said synchronous machine is calculated by considering the rotational frequency of said synchronous machine, and input direct current voltage of said power converter as an input. Said magnet temperature presumption means It is the control unit of the electric rolling stock according to claim 2 which presumes said magnet temperature from this presumed induced voltage and said temperature presumption table, and is characterized by said magnet temperature compensation means compensating the current command of said dq shaft current based on this magnet temperature estimate, Id compensation table, and Iq compensation table.
[Claim 4] Said induced voltage presumption means is the control unit of the electric rolling stock according to claim 3 characterized by having the function which amends said q shaft electrical-potential-difference command value according to the input direct current voltage of said power converter.
[Claim 5] Said Id compensation table and said Iq compensation table of said magnet temperature compensation means are the control unit of the electric rolling stock according to claim 3 characterized by being constituted so that the current command compensation value of said said dq shaft current may be outputted by considering output command of said synchronous machine, and said magnet temperature estimate as an input.
[Claim 6] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control unit of the electric rolling stock equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The temperature

presumption table which gives the induced voltage of said synchronous machine and the relation of temperature it is decided with the ingredient of a permanent magnet that will be an induced voltage presumption means to presume the induced voltage of said synchronous machine, The control unit of the electric rolling stock characterized by having a magnet temperature presumption means to presume the magnet temperature of said synchronous machine from the presumed induced voltage of said synchronous machine, and said temperature presumption table, and an abnormality judging means to detect demagnetization of the permanent magnet of said synchronous machine based on the magnet temperature of said presumed synchronous machine.

[Claim 7] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control unit of the electric rolling stock equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature it is decided with the ingredient of a permanent magnet that will be an induced voltage presumption means to presume the induced voltage of said synchronous machine, A magnet temperature presumption means to presume the magnet temperature of said synchronous machine from the presumed induced voltage of said synchronous machine, and said temperature presumption table, The control unit of the electric rolling stock characterized by having an abnormality judging means to detect demagnetization of the permanent magnet of said synchronous machine based on the magnet temperature of said presumed synchronous machine, and a command amendment means to amend a command value in order to compensate the output of said synchronous machine according to demagnetization of said permanent magnet.

[Claim 8] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control unit of the electric rolling stock equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature it is decided with the ingredient of a permanent magnet that will be an induced voltage presumption means to presume the induced voltage of said synchronous machine, A magnet temperature presumption means to presume the magnet temperature of said synchronous machine from the presumed induced voltage of said synchronous machine, and said temperature presumption table, The control unit of the electric rolling stock characterized by having an abnormality judging means to detect demagnetization of the permanent magnet of said synchronous machine based on the magnet temperature of said presumed synchronous machine, and a magnet temperature-compensation means to compensate the output of said synchronous machine according to the rise of said magnet temperature estimate, and demagnetization of said permanent magnet.

[Claim 9] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control approach of the electric rolling stock by the control unit equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The induced voltage of said synchronous machine is presumed with an induced voltage presumption means. With a magnet temperature presumption means The magnet temperature of said synchronous machine is presumed from the temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature which are decided with the ingredient of a permanent magnet, and

the presumed induced voltage of said synchronous machine. With a magnet temperature magnet temperature-compensation means The control approach of the electric rolling stock characterized by compensating said dq shaft command value with a command amendment means according to the rise of said presumed magnet temperature.
[Claim 10] The permanent-magnet type synchronous machine using a magnetic pole location sensor, and the power converter which drives said synchronous machine, A current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control approach of the electric rolling stock equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The induced voltage of said synchronous machine is presumed with an induced voltage presumption means. With a magnet temperature presumption means The magnet temperature of said synchronous machine is presumed. the temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature which are decided with the ingredient of a permanent magnet, and the presumed induced voltage of said synchronous machine -- ** -- since -- with an abnormality judging means The control approach of the electric rolling stock which detects demagnetization of the permanent magnet of said synchronous machine based on the magnet temperature of said presumed synchronous machine, and is characterized by compensating the output of said synchronous machine according to demagnetization of said permanent magnet with a command amendment means.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the control device and the control approach of electric rolling stock, and relates to the control device and the control approach of electric rolling stock which were especially equipped with the synchronous machine using a magnetic pole location sensor like the permanent-magnet type synchronous motor as a wheel driving source, or the permanent-magnet type synchronous generator for dc-battery charge.
[0002]
[Description of the Prior Art] the control unit which drives the AC motor for electric rolling stock conventionally -- as a motor -- an induction motor -- be -- the synchronous motor using a permanent magnet -- be -- vector control which decomposes into the torque current Iq and an exciting current Id, and controls the current of a motor is put in practical use. The electrical potential difference of a motor is compensated in order to compensate the loss of power by the temperature rise of the magnet of this permanent-magnet type synchronous motor, and the current pan is compensated with JP,7-212915,A only for q shaft current command Iq* based on a temperature sensor.
[0003]
[Problem(s) to be Solved by the Invention] The output characteristics accompanying the temperature change of the magnet of a permanent-magnet type synchronous motor change with magnet ingredients. For example, the fall of the induced voltage by temperature is [about] with a ferrite magnet. -It is -0.1%/degree C with 0.2%/degree C and a NEOJI magnet. The output or torque of a motor falls by the fall of such induced voltage.
[0004] With the synchronous motor and synchronous generator which raised the packaging density of a device in order to high-performance-ize, small and a magnetic temperature rise becomes remarkable especially about equipment, and the output of a synchronous machine or the fall of torque is remarkable.
[0005] Such a magnet temperature rise of a permanent-magnet type synchronous machine is detected, the magnet temperature of Rota is indirectly presumed as a means to compensate the loss of power accompanying a temperature rise, from the core temperature of the stator of the synchronous machine carried in electric rolling stock, and it is possible to compensate loss of power. However, according to the experiment, between the core temperature of a stator, and the magnet temperature of Rota, an about **30-degree C temperature error arises at the time of the rise of magnet temperature, or descent. Therefore, the method of presuming magnet temperature based on core temperature, and compensating loss of power cannot compensate the output of a synchronous machine enough, and cannot secure output precision.
[0006] How to detect the electrical potential difference by which is made to suspend an inverter, is made to race a synchronous machine as an approach of detecting correctly the output fluctuation accompanying the temperature rise of a permanent-magnet type synchronous machine, and induction is carried out can be considered. However, although it is possible, where a synchronous machine is carried in actual electric rolling stock, it cannot perform performing this approach in a laboratory.
[0007] On the other hand, demagnetization of a permanent magnet is also considered besides a magnetic temperature rise as the output of a permanent-magnet type synchronous machine, or a fall factor of torque.
[0008] This invention presumes exactly the magnet temperature rise of the synchronous machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine, compensates output fluctuation, and aims at offering the control unit and the control approach of the electric rolling stock in which good transit control is possible.
[0009] Other purposes of this invention presume exactly the magnet temperature rise of the synchronous

machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine, and demagnetization of a permanent magnet, and aim at offering the control unit of the electric rolling stock which can perform output compensation and other required treatment.
[0010]
[Means for Solving the Problem] The permanent-magnet type synchronous generator with which the magnetic pole location sensor was used for this invention, and the synchronous machine of a motor, The power converter which drives said synchronous machine, a current command generating means to generate d shaft current command of a synchronous machine, and q shaft current command, dq shaft current from dq shaft current command and a synchronous machine current based on a detection value dq shaft electrical-potential-difference command value Vd*, Vq*, Alternating-voltage command value Vu*, Vv*, Vw*, dq shaft current control means that performs coordinate transformation processing and performs further phase data processing used by coordinate transformation processing from a magnetic pole location sensor and an angle sensor, and a rate operation, In the control unit of the electric rolling stock equipped with an PWM means to output the signal which drives the power component of said power converter from said alternating-voltage command value The temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature it is decided with the ingredient of a permanent magnet that will be an induced voltage presumption means to presume the induced voltage of said synchronous machine, It is characterized by establishing a magnet temperature presumption means to presume the magnet temperature of said synchronous machine from the presumed induced voltage of said synchronous machine, and said temperature presumption table, and a magnet temperature-compensation means to compensate the output of said synchronous machine according to the rise of the magnet temperature of said presumed synchronous machine.
[0011] Said induced voltage presumption means has other descriptions of this invention in inputting q shaft electrical-potential-difference command value Vq*, d shaft current command value Id*, a rotational frequency, and the input voltage of a power converter.
[0012] Other descriptions of this invention are based on the magnet temperature estimate which is an output value of said magnet temperature presumption means to compensate current command Id* of q shaft current, and Iq*.
[0013] The permanent-magnet type synchronous machine with which the magnetic pole location sensor was used for other descriptions of this invention, The power converter which drives said synchronous machine, and a current command generating means to generate d shaft current command of said synchronous machine, and q shaft current command, dq shaft current control means which generates dq shaft electrical-potential-difference command value based on the current detection value of said d, q shaft current command, and said synchronous machine, performs coordinate transformation processing and generates an alternating-voltage command value, In the control approach of the electric rolling stock by the control unit equipped with the PWM control means which outputs the signal which drives the power component of said power converter from said alternating-voltage command value The induced voltage of said synchronous machine is presumed with an induced voltage presumption means. With a magnet temperature presumption means The magnet temperature of said synchronous machine is presumed from the temperature presumption table which gives the induced voltage of said synchronous machine and the relation of temperature which are decided with the ingredient of a permanent magnet, and the presumed induced voltage of said synchronous machine. With a magnet temperature magnet temperature-compensation means It is in compensating the output of said synchronous machine according to the rise of said presumed magnet temperature.
[0014] According to this invention, since magnet temperature is presumed from presumed induced voltage and a temperature presumption table, the magnet temperature rise of the synchronous machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine can be presumed exactly, output fluctuation can be compensated, and the control unit and the control approach of the electric rolling stock in which good transit control is possible can be offered.
[0015] Moreover, the magnet temperature rise of the synchronous machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine and demagnetization of a permanent magnet can be presumed exactly, and output compensation and other required treatment can be performed.
[0016]
[Embodiment of the Invention] Hereafter, drawing explains the example of this invention. First, drawing 1 shows the configuration of the drive control system for electric rolling stock which becomes one example of this invention. A motor 1 is a permanent-magnet type synchronous motor, and uses an inverter 2, i.e., an

inverter, as a power converter. The magnetic pole position transducer 4 which detects the encoder 3 and magnetic pole location which are the angle-of-rotation sensor is directly linked with the permanent-magnet type synchronous motor 1. The motor control unit 5 generates an PWM signal based on the output of an encoder 3 and the magnetic pole position transducer 4, and the output of the current detector 6, and controls an inverter 2.

[0017] The drive system control section 11 is controlled so that delivery and a motor 1 generate the torque corresponding to the control input of an accelerator pedal and a brake pedal for motor torque command tauM* according to the control input of an accelerator pedal and a brake pedal in the motor control device 5. The motor control unit 5 is equipped with dq shaft current control function which generates dq shaft current command value and an alternating-voltage command value based on the output of an encoder 3 and the magnetic pole position transducer 4, and the output of the current detector 6, and the PWM signal generation function which generates the PWM signal which controls an inverter 2 based on an alternating-voltage command value. The inverter 2 was constituted by six power components (IGBT) and each power component using the diode connected to juxtaposition, and is equipped with the three-phase-circuit bridge circuit which controls the current which flows to the coil of U [of a motor 1], V, and W each phase, and one smoothing capacitor.

[0018] The power source of the permanent-magnet type synchronous motor 1 is supplied through a converter 10 from the permanent-magnet type synchronous generator 9 driven by the dc-battery 7 or the gasoline engine 8. Moreover, a dc-battery 7 is charged with the permanent-magnet type synchronous generator 9.

[0019] The detail functional block diagram of the motor control device 5 which controls the permanent-magnet type synchronous motor 1 to drawing 2 is shown. The motor control unit 5 is equipped with 3 / 2 phase-number conversion means 202, the IdIq current control means 204, the 2 / three-phase-circuit conversion means 206, the PWM control means 208 and the phase operation means 210, and the rate operation means 212. The input side of the rate operation means 212 is connected to an encoder 3, and the input side of the phase operation means 210 is connected to the encoder 3 and the magnetic pole location detection means 4. The motor control unit 5 is further equipped with the current command generating means 220 including the Iq control means 224 and the Id control means 226.

[0020] The motor control unit 5 is equipped with a magnet temperature presumption means 232 to presume the magnet temperature of the permanent-magnet type synchronous motor 1, a magnet temperature-compensation means 234 to compensate a motor output with the rise of magnet temperature, a magnet malfunction detection means 242 to detect magnetic demagnetization, and the magnet temperature-compensation means 230 including the command amendment means 244 which carries out output amendment according to the magnetic amount of demagnetization again. The magnet temperature presumption means 232 is equipped with the temperature presumption table 2322 for presuming the magnet temperature TMG to be an induced voltage presumption means 2321 to calculate the presumed induced voltage of a synchronous machine by considering the rotational frequency omega of q shaft electrical-potential-difference command value Vq*, d shaft current command value Id*, and a synchronous machine, and direct current voltage VB of a power converter 2 as an input from this presumed induced voltage.

[0021] The permanent-magnet type synchronous generator 9 is also equipped with the control unit (not shown) including a magnet temperature-compensation means including the same magnet temperature presumption means as the motor control unit 5, the magnet temperature-compensation means, magnet malfunction detection ****, and the command amendment means of the permanent-magnet type synchronous motor 1. Hereafter, the motor control unit 5 is explained and explanation of the control unit of the permanent-magnet type synchronous generator 9 is omitted.

[0022] Command value Iq* of q shaft current which is equivalent to a torque part current in the motor control unit 5 is torque command value tauM*. It computes by the Iq control means 224 based on a rotational frequency. On the other hand, command value Id* of d shaft current is also computed by the Id control means 226 based on torque command value tauM* and a rotational frequency. Thus, Id in a motor control device and the Iq table 224,226 are current command value Iq* required of efficient control based on the torque command value tauM0 and a rotational frequency, and Id*. It computes.

[0023] 3 / 2 phase coordinate transformation means 202 performs coordinate transformation processing of 3/2 phase for the three-phase-circuit alternating current of the motor current detected with the current detector 6, and computes d and the q shaft currents Id and Iq. These detection values Id and Iq and command value Id*, Iq* On a basis, the IdIq current control means 204 performs proportionality or proportional integral current control processing, and computes electrical-potential-difference command value Vd* and

Vq*.
[0024] Furthermore, in 2 / three-phase-circuit conversion means 206, coordinate transformation of 2/three phase circuit is performed, and they are three-phase-circuit alternating-voltage command value VU*, VV*, and VW*. It computes. the PWM control means 208 -- this electrical-potential-difference command value VU*, VV*, and VW* from -- comparison processing with the carrier signal of a triangular wave signal is performed, an PWM signal is generated, and an inverter 2 is driven. Thus, by impressing the electrical potential difference by which PWM control was carried out to a motor 1, a motor current is current command value Iq* and Id*. It controls in agreement.
[0025] In addition, the phase angle theta 1 used by 2 / three-phase-circuit transform processing 206, and coordinate transformation processing of a three phase circuit / 2 phase coordinate transformation means 202 is computed in the phase operation means 210 from the induced voltage of a motor 1, and each output of the magnetic pole position transducer 4 which outputs a signal in phase, and the encoder 3 which outputs an angle-of-rotation signal (pulse signal).
[0026] The phase relation between the output signal of this magnetic pole position transducer 4 and the phase angle theta 1 of the motor control unit 5 interior to the motor current I1 and induced voltage E0 is shown in drawing 3 . A phasing signal is calculated with a phase operation means 210 to accumulate the pulse signal of an encoder 3, and turns into a saw-tooth-wave-like signal. The magnetic pole position signal which is an output signal of the magnetic pole position transducer 4 is synchronized with the induced voltage E0 of a motor 1. By performing such processing, the motor control unit 5 is torque command value tauM*. Efficient control which is torque and makes loss min is performed.
[0027] The vector diagram of the motor 1 at that time is shown in drawing 4 . Iq* for acquiring an efficient point, and Id* It is controlled by optimal angle-of-lead beta (beta=tan -1 (Id*/Iq*)). In addition, the reference point of angle-of-lead beta is drawing 3 at the shown t0 time, and shows the current I1 currently controlled at this t0 time with a broken line.
[0028] The output torque of a motor 1 is shown by (1) type.
tauM=Pn [{E0+(1-rho) LdId} Iq] -- (1) However, Pn of a constant and rho is [the ratio of Lq and Ld and E0] induced voltage.
[0029] (1) In the formula, the 1st term of the right-hand side is called synchronous torque, and the 2nd term is called reactance torque.
[0030] The torque characteristic which considered as the applied-voltage regularity to a motor, and made angle-of-lead beta adjustable comes to be shown in drawing 5 . The sum of synchronous torque and reactance torque is generating torque tauM. Thus, since angle-of-lead beta generates the maximum torque near 45 degrees, the synchronous motor in which rho of (1) type has a larger reverse salient pole property than 1 is controlled above this include angle. An electric vehicle is driven in such actuation.
[0031] Next, actuation of temperature-compensation control of a motor is explained below by drawing 6 . First, the induced voltage E0 to the magnet temperature TMG of a permanent-magnet type synchronous motor and the relation of an output torque characteristic are shown in drawing 6 . It turns out with the rise of the magnet temperature TMG that induced voltage and an output torque decline.
[0032] The electrical potential difference of a synchronous machine and the basic type of a current are as being shown in a degree type.
Vd=Xq-Iq-r1, Id Vq=E0+Xd-Id+r1, Iq -- (2) If r1 is disregarded here Vd=Xq-Iq Vq=E0+Xd-Id -- (3) By the reason E0= Vq-Xd-Id It becomes.
[0033] Here, it is Vq, Electrical-potential-difference command value Vq* in the motor control unit 5 and Xd use the fixed value standardized by 1/300min. Id uses command value Id*.
[0034] Induced voltage E0 increases in proportion to the rotational frequency of a synchronous machine. Then, induced voltage E0 is standardized at the specific rotational frequency omega. For example, the induced voltage E010 standardized by 1/300min is as follows.
[0035]
E010= E0x (omega3000/omegar) -- (4)
By the reason E010=(omega3000/omegar) x {(VB0/VB) x Vq*-Xd-Id*}
= k1, Vq*-k2, and Xd-Id* -- (5) In (5) types, electrical-potential-difference command value Vq* is amended with direct current voltage VB. VB0 is a design value and VB is an actual measurement. Since it is a signal for generating a real PWM signal, by amending with the magnitude of VB can show electrical-potential-difference command value Vq* within the motor control unit 5 as Vq* shown in a vector diagram like drawing 4 . Moreover, in (5) types, adjustable [of the multiplier of k1 and k2] is carried out by rotational frequency omegar, and E010 is calculated.

[0036] The magnet temperature presumption means 232 presumes the magnet temperature TMG from the presumed induced voltage E010 for which it asked with the induced voltage presumption means 2321, and the relation of the temperature presumption table 2322.
[0037] Moreover, magnet temperature shows the motor control action vector diagram at the time of low temperature to (a) of drawing 7 , and magnet temperature shows the motor control action vector diagram at the time of an elevated temperature to (b). In these vector diagrams, Xd and Xq are dq shaft impedances, As it is shown by Xd=omega fLd and Xq=omega fLq and is shown in drawing 8 , Ld becomes fixed regardless of Id and Lq decreases according to Iq.
[0038] In drawing 7 , induced voltage E decreases like E00>E01 by the magnet temperature rise. A motor electrical potential difference decreases in connection with it (V10> V11). Consequently, a power-factor is changed and an output torque decreases. then, with reference to a temperature presumption table, the magnet temperature TMG is presumed from the presumed induced voltage E010 based on the operation expression of (5) -- compensation of Id and Iq is performed.
[0039] Thus, this invention is characterized by compensating output fluctuation of the synchronous machine accompanying change of the magnet temperature TMG according to compensation of current command value Id* and Iq*.
[0040] That is, the magnet temperature compensation means 234 is equipped with Id compensation table 2341 and Iq compensation table 2342 as shown in the detail block diagram of drawing 9 R> 9. These Id(s) compensation table 2341 and Iq compensation table 2342 output the compensation multipliers Kd and Kq which compensate current command Id* of dq shaft current, and Iq* based on the output command tauM0 and the magnet temperature TMG of a synchronous machine.
[0041] Drawing 10 and 11 show an example of Id of a magnet temperature compensation control means, and the data of Iq table. Id table of drawing 10 is the magnet temperature estimate TMG and the torque command value equivalent value tauM0. By inputting, the compensation multiplier Kd of current command value Id* is obtained. Iq table of drawing 11 is the magnet temperature estimate TMG and the torque command value equivalent value tauM0. By considering as an input, the compensation multiplier Kq of current command value Iq* is obtained.
[0042] The magnet temperature presumption means 232 shows the presumed procedure of magnet temperature in which the temperature presumption table 2322 was used to drawing 12 .
[0043] First, it is equal in the immediately after [starting of a motor], and core temperature TM 2, and the presumed magnet temperature TMGO (E020 ((2) of drawing 12) obtained with reference to the temperature presumption day full 2322 as (1) of drawing 12 is compared with EO10 computed by (5) formulas, and multiplier k1.k2 are beforehand matched and placed so that it may be set to E020=EO10.). The magnet temperature TMG1 is presumed by doing so from EO10 computed by (5) formulas working. ((4) of drawing 12) The magnet temperature TMG10 presumed by doing in this way becomes a thing very near the magnet temperature of an actual synchronous machine. Therefore, according to the approach of this invention, as shown in drawing 13 , exact temperature compensation which followed change of actual magnet temperature can be performed, and the control precision of an output torque improves compared with the presumed method from core temperature.
[0044] The magnet temperature TMGO may be presumed using a temperature presumption table from the ratio ((1) of drawing 14) of the EO10 and the induced voltage EO100 with a magnet temperature of 100 degrees C which were computed by (5) formulas as a magnet temperature presumption means which becomes other examples of this invention as shown in drawing 14 .
[0045] When presumed magnet temperature reaches the magnetic permission demagnetization temperature TMGMAX in drawing 12 and 14, the abnormality judging means 242 performs exception processing, such as a system stop. As a result of exceeding the permission demagnetization temperature TMGMAX somewhat and measuring the induced voltage after a system stop, when extent of demagnetization can be small and can operate, the magnet temperature presumption means 232 presumes the magnet temperature newly presumed in the property (alternate long and short dash line) of the temperature presumption table 2322. Since an output decreases by having demagnetized some, the command amendment means 244 increases torque command tauM* as much as possible, the magnet temperature-compensation means 234 performs temperature compensation further, and operation is continued, supervising magnet temperature with the abnormality judging means 242.
[0046]
[Effect of the Invention] According to this invention, since magnet temperature is presumed from presumed induced voltage and a temperature presumption table, the magnet temperature rise of the synchronous

machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine can be presumed exactly, output fluctuation can be compensated, and the control unit of the electric rolling stock in which good transit control is possible can be offered.

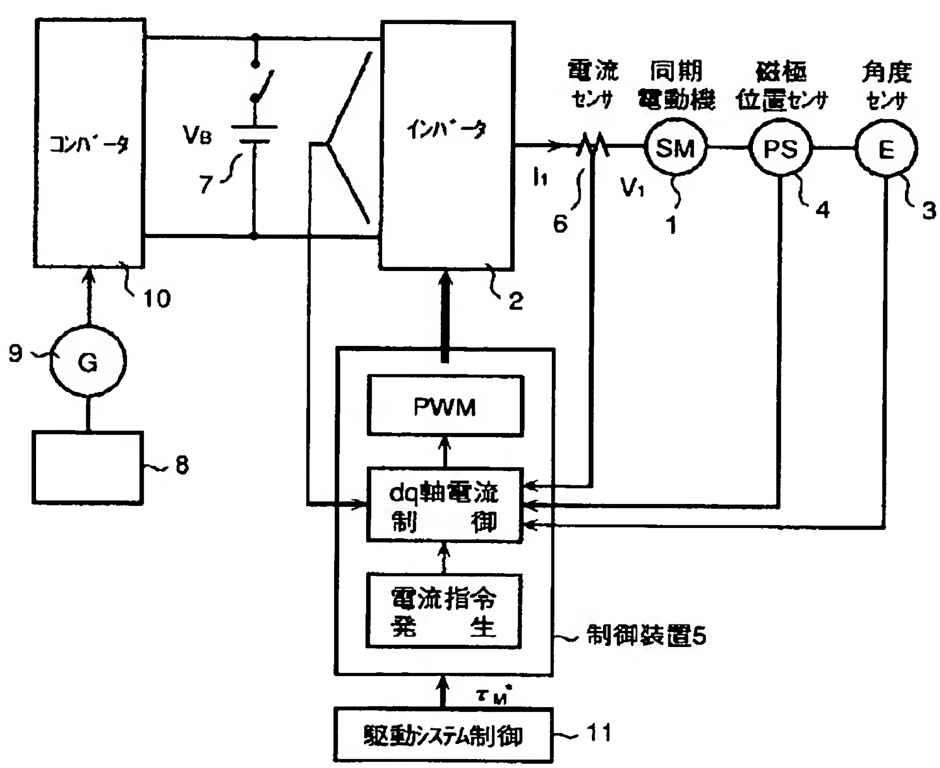
[0047] According to this invention, the magnet temperature rise of the synchronous machine in the electric rolling stock equipped with the permanent-magnet type synchronous machine and demagnetization of a permanent magnet can be presumed exactly again, and output compensation and other required treatment can be performed.

[Translation done.]

DRAWINGS

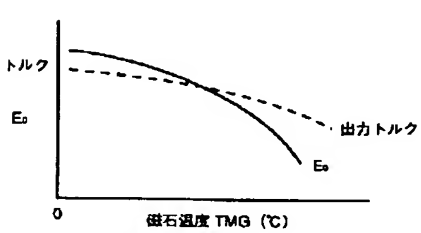
[Drawing 1]

図 1



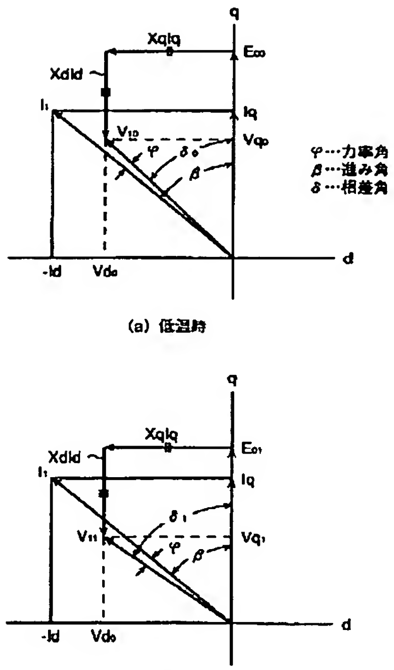
[Drawing 6]

図 6



[Drawing 7]

図 7

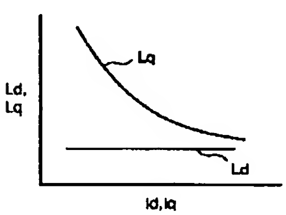


(a) 低温時

(b) 高温時

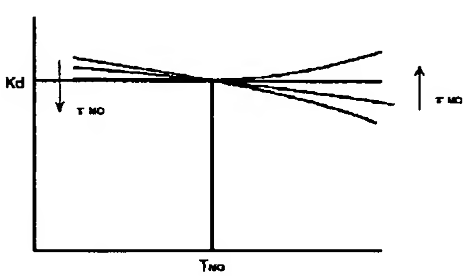
[Drawing 8]

図 8



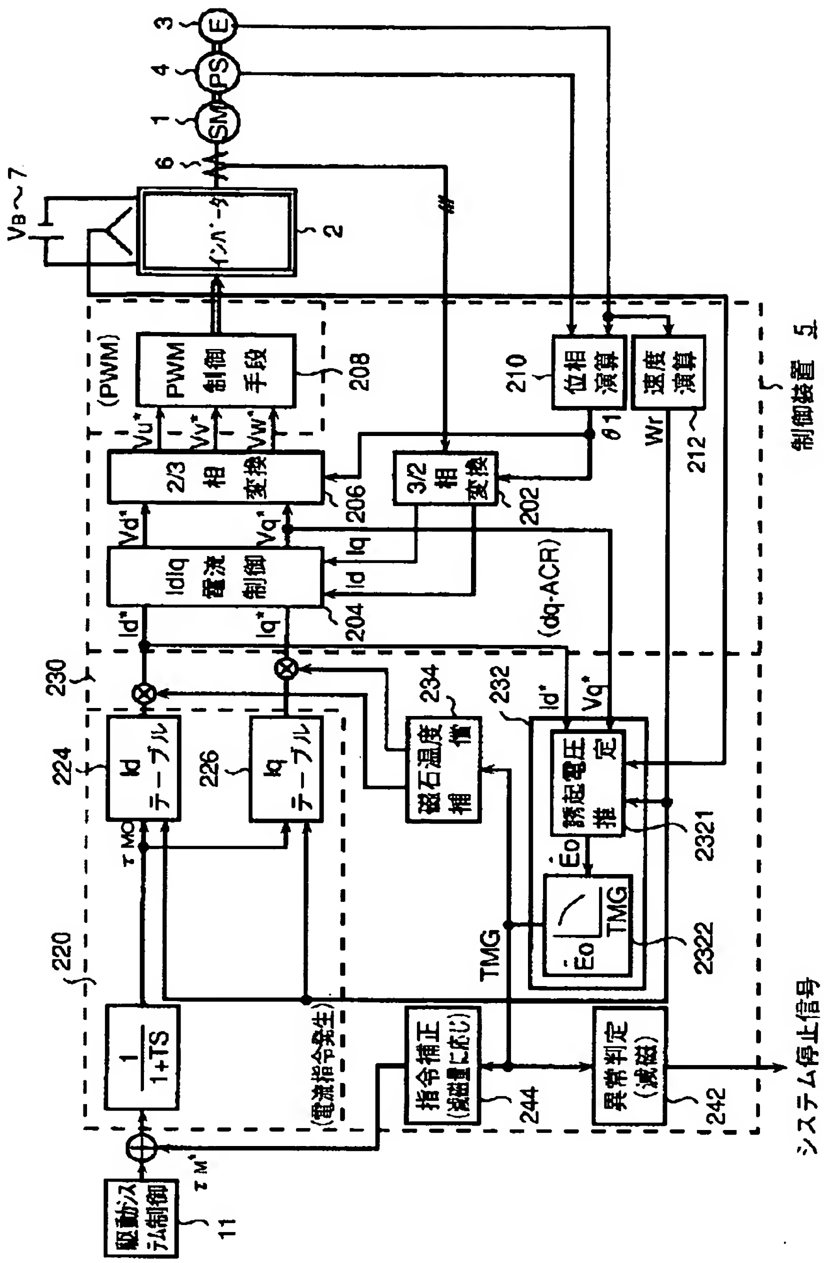
[Drawing 10]

図 10



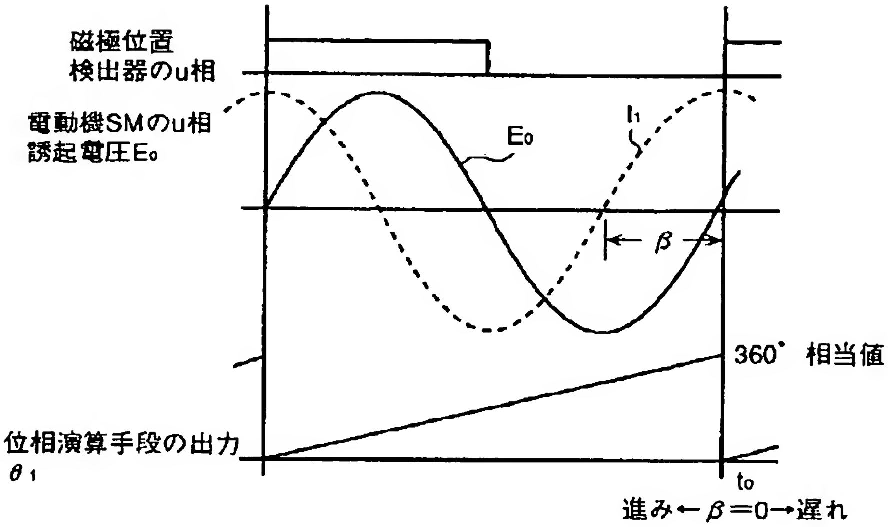
[Drawing 2]

図 2


インバータ
PWM制御手段
(PWM)
2/3相変換
3/2相変換
IdIq電流制御
(dq-ACR)
位相演算
速度演算
Idテーブル
Iqテーブル
(電流指令発生)
磁石温度補償
誘起電圧推定
TMG
指令補正(減磁量に応じ)
異常判定(減磁)
システム停止信号
制御装置 5
駆動システム制御
SM
PS
E

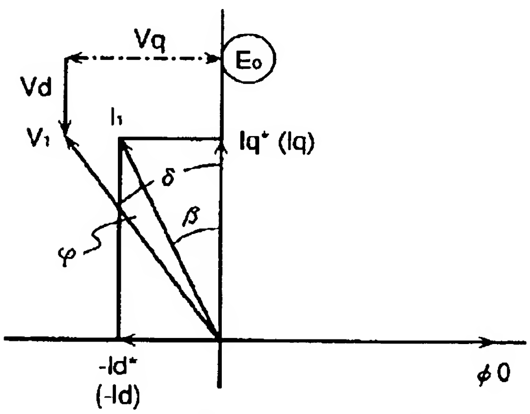
[Drawing 3]

図 3



[Drawing 4]

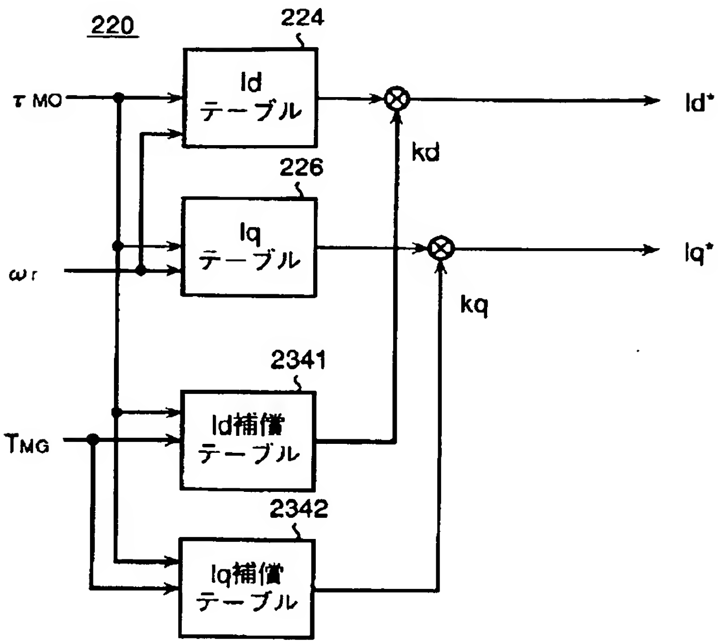
図 4



E0…磁石の誘起電圧　V1…端子電圧
δ…負荷角　φ…力率角　β…進み角

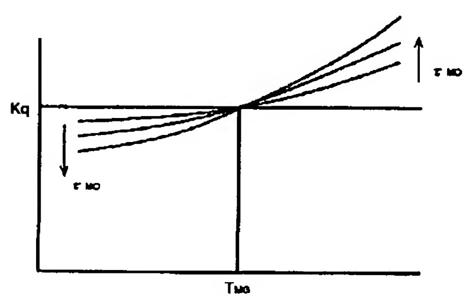
[Drawing 9]

図 9



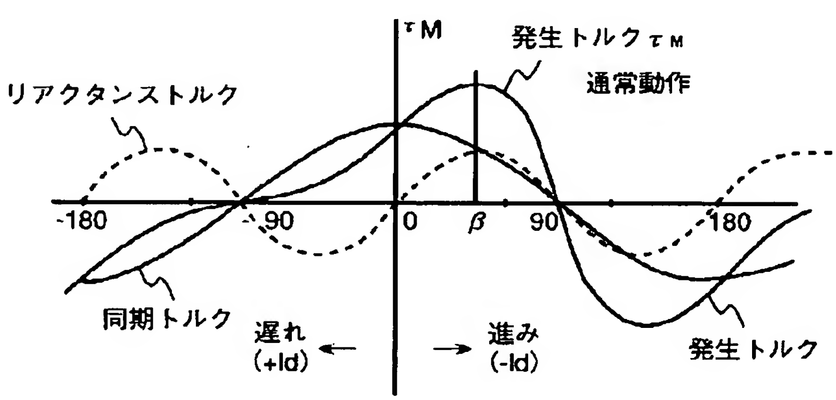
[Drawing 11]

図 11



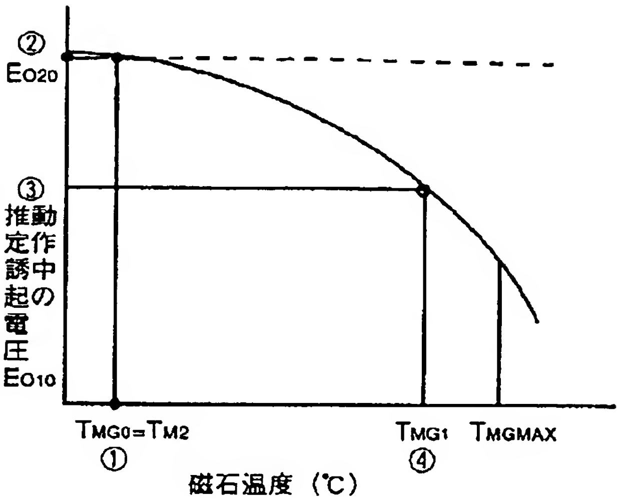
[Drawing 5]

図 5



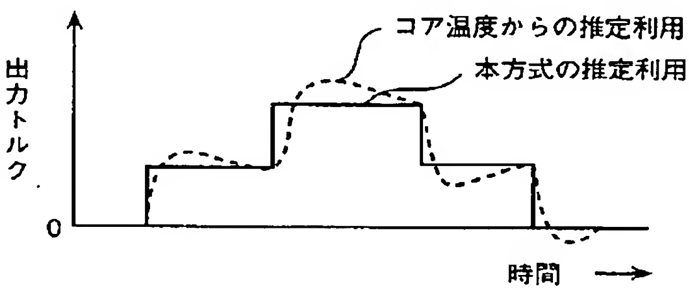
[Drawing 12]

図 12



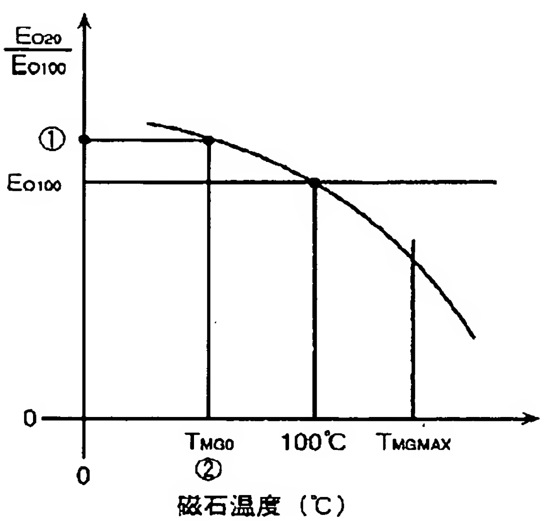
[Drawing 13]

図 13



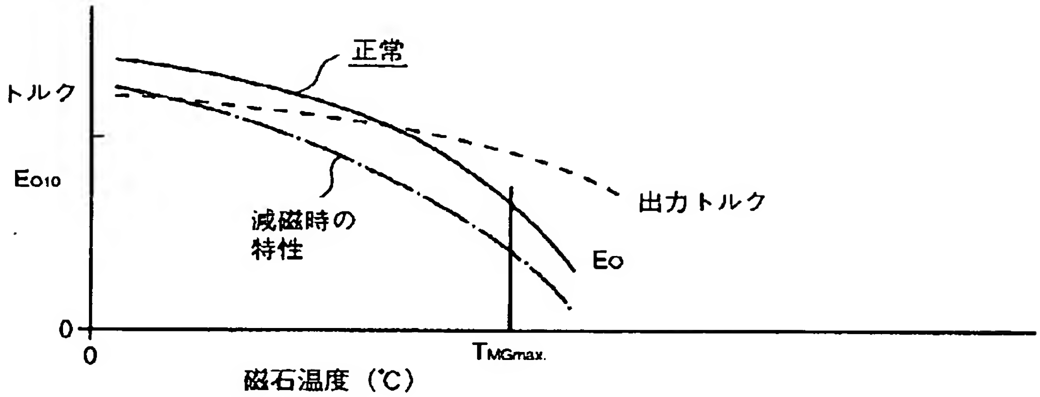
[Drawing 14]

図 14



[Drawing 15]

図 15



[Translation done.]